Claims 48 and 50-54 were rejected under 35 USC § 102(e) as anticipated by Sim (U.S. Patent No. 6,117,773), by De Bruin (U.S. Patent No. 5,240,879), and by the previously cited reference to Chen (U.S. Patent No. 5,525,543).

Independent claim 48 is amended to recite specifically that the different elements of the planar layer are "a refractory metal and the first material," i.e., the material of the bottom surface. The Office Action asserts on page 2 that Sim's bottom layer 32 (Figs. 3B, 3C) has the "graded stoichiometry" recited in claim 48. However, Applicant is unable to find any indication within the text or drawings that the ratio of titanium to silicon in silicide layer 32 varies with depth in any "graded" manner, and respectfully requests the specific basis within the reference itself for such an assertion.

The Office Action also asserts on page 7 that De Bruin's Fig. 4 discloses the structure of claim 48. However, Applicants finds no indication in this reference that layer 15b, corresponding to the "planar layer ... covering only the bottom surface," has anything other than a constant stoichiometry. Only De Bruin's sidewalls have a varying stoichiometry, from top to bottom; the bottom layer itself must constant---otherwise parts of it would be selectively etched away when the sidewall layers are removed; see col. 4 lines 9-34.

The Chen patent teaches a TiN_x film having a variable stoichiometry at col. 2 lines 24-28. Amended claim 48, however recites that the layer having the graded stoichiometry comprises "a refractory metal and the first material" of the bottom surface. Chen's nitride film does not incorporate any of the bottom surface material, such as silicon. Although Chen subsequently forms a silicide film on the bottom surface, he does not suggest that that film has a variable or graded stoichiometry.

Dependent claims 49-54 incorporate the recitations of their parent claim 48. Claim 49 was rejected under 35 USC § 103(a) as unpatentable over Chen in view of Miyamoto (U.S. 5,831,335). The only purpose of Miyamoto is to introduce the aspect ratio of the hole; Miyamoto does not supply any of the above-noted deficiencies of the primary Chen patent.

New independent claim 108 is also drawn to the graded stoichiometry feature of the present invention. As in claim 48, the generally planar layer is a "silicide" having "a graded stoichiometry" and located "on the bottom surface." As in claim 48, the cited references fail to teach this combination of recitations. New dependent claims 109-113 also integrate these recitations. Claim 110 specifies the silicide as including "cobalt," as described on page 17 line11

of the Specification. Claim 113 emphasizes that grading occurs "only" on the bottom of the hole.

Claims 82, 83, 85, and 86 were rejected under 35 USC § 102(e) as anticipated by Sim and by De Bruin. Applicant respectfully traverses these rejections. As noted earlier, Sim's layer 32 on the bottom of the hole appears to have a constant ratio of constituents, not the "graded stoichiometry" recited in parent claim 82. Although de Bruin's hole's sidewall has a graded stoichiometry, the "planar bottom layer" is not graded as featured in claim 82.

Dependent claims 83-86 include these features of their parent. Claim 84 was rejected under 35 USC § 103(a) as being unpatentable over Sim in view of Chen. Applicant respectfully traverses this rejection. Sim appears to have no graded stoichiometry at all, nor any reason to include one. Chen's sidewalls contravene the claim recitation that the sidewall consists "substantially entirely of ... insulator material," and suggests neither a reason nor a means to remove his TiN layer from the sidewall. Therefore, the combination of these references is not motivated within the four corners of either of them, but rather only by Applicant's disclosure. This is not permitted under 35 USC § 103(a), as explained in *In re Lee*, 61 USPQ2d 1430 (Fed. Cir. 2002).

Independent claims 104-106 were rejected under 35 USC § 102(e) as being anticipated by Sim and by De Bruin. Claim 104 is canceled, and claim 105 is amended to depend from claim 106. The rejections of claim 106 are respectfully traversed.

Claim 106's recitation of an insulating sidewall and a silicide on the bottom layer restrict the relevant references to Sim and De Bruin. However, as discussed in connection with claim 82, neither of these patents teaches or suggests the "graded stoichiometry" of the planar bottom layer that is incorporated into claim 106.

Dependent claims 105, 107, and 114 include the features of parent claim 106. Claim 107 was rejected under 35 USC § 103(a) as unpatentable over Sim in view of Chen. However, this combination cannot be motivated by teachings within the references themselves, as pointed out in connection with claim 84 above.

Claims 71-76, 87-96, and 98-103 were rejected as anticipated under 35 USC § 102(e) by Sim and by De Bruin. Independent claim 71 has been amended to emphasize another feature of the invention, the reduction of substrate depletion. The Sim patent admits to depletion of the substrate, but attempts to counteract the resulting leakage by implanting doped species below the

bottom of the contact hole, within the substrate. De Bruin does not even recognize the depletion problem, although he deposits pure Ti or W metal directly upon the silicon and anneals it to form a silicide. The Specification points out on page 3 lines 7-15 that this action consumes the substrate silicon. Chen and Miyamoto (not applied against these claims) both recognize the depletion problem. Chen asserts that his process decreases the resulting leakage by another means. Miyamoto deposits a pure Ti film without etching the substrate, but then proceeds to deplete the substrate anyway, when the metal film is later converted to a silicide.

Applicant ameliorates the depletion problem by sputtering---and resputtering---a $TiSi_x$ or other alloy target to form the bottom layer. Since the incoming material already contains the substrate material, e.g., silicon, no annealing is required to form the silicide, so the substrate need not be appreciably depleted. Although Applicant does employ a subsequent annealing to remove native oxides, the Specification states at page 5 lines 18-19 note that the already existing TiSi material inhibits silicon consumption. For example, if the deposited layer already has a 1.8:1 ratio, almost no silicon need be consumed to convert the layer to the 2.0:1 minimum-energy ratio.

Amended claim 71 expresses this lack of depletion by reciting that the substrate has a profile "that does not change significantly" in the vicinity of the contact hole, as described in the Specification on page 15 lines 1-10. For the reasons given above, the cited references change the profile of the substrate at the edge of the contact hole by eating into the substrate material and changing its profile with a significant dip. This effect occurs whether or not a reference recognizes it, unless explicit steps are taken to alleviate it, as Applicant has done.

New dependent claim 115 quantifies Applicant's advantage by reciting that the profile change, i.e., the depth of substrate depletion, is "less than twice the thickness of the generally planar layer." The Specification describes at page 3 lines 13-15 that the substrate silicon consumed is twice as thick as the deposited metal, because the minimum-energy stoichiometry requires two atoms of Si for every atom of Ti. Dependent claims 72, 73, 75(Amended) and 76(Amended) include the recitations of parent claim 71.

Independent claim 98 is amended to embrace the depletion-avoidance feature of the invention in the context of an integrated circuit. In the context of an insulating sidewall and a silicide bottom layer, claim 98 recites that that substrate profile "does not change significantly" at the contact hole. As noted in connection with claim 71, none of the cited references teaches

this improvement. Although De Bruin's stylized Figs. 4 and 5 do not explicitly show the depletion, it occurs nonetheless.

Dependent claims 99-103 and 116 incorporate their parent claim recitations. New claim 116 quantifies the depletion-avoidance effect 6to less than that attainable by the references, as taught on page 3 lines 13-15 of the Specification.

Independent amended claim 87 expresses the depletion avoidance aspect by specifying that bottom layer extends into the substrate "less than twice the distance from the top of the bottom layer to the top of the substrate." As explained above, the pure metal layers of the references consume at least twice their thickness of substrate material. Claim 87, however, states that the substrate penetration of the invention is less than that amount.

Dependent claims 88, 89, 91(Amended), and 92(Amended) incorporate all the features of their parent claim 87.

Independent claim 93 is amended to express the depletion depth more generally. The two-times relationship on page 3 lines 13-15 of the Specification occurs, as it states, because one atom of the metal requires two of the silicon of the substrate. It is a trivial step to generalize this to other metals and other substrate materials. Claim 93 accordingly sets forth the maximum depletion depth, i.e., the distance below the top of the substrate, as "less than the equilibrium ratio of the metal and the substrate material times the thickness of the bottom layer above the top of the substrate." Obviously, this reduces to two times for the particular case of $TiSi_2$.

Dependent claims 94-97 include the features of claim 93. Claims 96 and 97 adduce the graded stoichiometry not taught by the references, as argued above.

Conclusion

For the above reasons, Applicant urges that the claims meet all the statutory requirements, and respectfully requests their reexamination and allowance. The Examiner is invited to telephone Applicant's attorney at (612) 373-6971 to facilitate prosecution of this Application.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

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Date 26 Feb 2003

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CERTIFICATE UNDER 37 CFR 1.8: The undersigned hereby certifies that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail, in an envelope addressed to: Commissioner of Patents, Washington, D.C. 20231, on this 26th day of February, 2003.

Amy Moriarty
Name

Signature